

Feb 6 1964

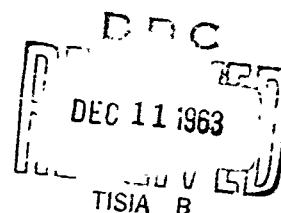
# MEASUREMENT OF GROUP EFFECTIVENESS IN NATURAL ISOLATED GROUPS

4244-4

E.K. ERIC GUNDERSON

PAUL D. NELSON

REPORT NUMBER 63-16



U. S. NAVY MEDICAL  
NEUROPSYCHIATRIC RESEARCH UNIT

SAN DIEGO 52 CALIFORNIA

BUREAU OF MEDICINE AND SURGERY NAVY DEPARTMENT

WASHINGTON, D. C. 20390

Measurement of Group Effectiveness in Natural Isolated Groups

by

E. K. Eric Gunderson, Ph. D.

and

Paul D. Nelson  
Lieutenant, MSC, U. S. Navy

United States Navy Medical Neuropsychiatric Research Unit

San Diego, California 92152

Report Number 63-16, October 1963, supported by the Bureau of Medicine and  
Surgery, Department of The Navy, under Research Task MR005.12-2004, Subtask 1

Prolonged isolation in a restricted environment places unusual stresses upon small groups. The specific effects of such stresses upon group cooperation and efficiency over long periods are largely unknown.

The study of interpersonal relations and performance in natural closed groups has been seriously handicapped by lack of operationally defined concepts, practical measurement techniques, and opportunities to apply them repeatedly. Most efforts to measure group interaction and effectiveness have taken place in laboratory or short-term field situations which have not permitted taking into account changes in group processes as a function of extended periods of time. This shortcoming becomes critical when a major focus of interest is the ability of groups to maintain positive social attitudes and effective work behaviors over extended periods of time.

The present report describes the development of a set of attitude measures designed to reflect individual reactions to and satisfaction with Antarctic station life and to assess several aspects of group interpersonal relationships and work effectiveness. These measures were applied to small groups of scientists and Navy personnel living and working together in complete physical isolation from the rest of the world for approximately twelve months at scientific stations on the Antarctic continent. The reactions of nine groups to the privations of long-term isolation and confinement were assessed at two time periods by means of these attitude measures. Group differences on the attitude measures were related to an independent criterion of group effectiveness.

During and since the International Geophysical Year of 1957 and 1958, the United States has maintained several stations on the Antarctic continent year-round to implement the Antarctic Research Program supported by the National Science Foundation and the United States Navy. Civilian scientists and technicians collected research data while Navy personnel provided necessary logistic support. Groups of from 15 to 40 men lived and worked together in close association for approximately a year. For from seven to nine months all stations were completely isolated from each other and the outside world, except for intermittent radio communication. There was no possible way for members to leave the station nor for help to reach them during this period.

The physical setting of the Antarctic stations is undoubtedly the most rugged environment inhabited by man. Temperatures below -100 degrees Fahrenheit have been recorded, winds of more than 100 miles per hour may prevail, and altitudes range up to nearly 10,000 feet above sea level at the Amundsen-Scott South Pole Station. During the Antarctic summer months, when sunlight is nearly continuous, construction, repair, and storage tasks must be performed at every station in addition to the collection of scientific data. These tasks must be accomplished if the group is to survive the savage onslaughts of Antarctic winter. With the advent of the winter season, a period of from approximately three to six months of continuous darkness depending upon geographical location, the men are forced indoors for all of their activities.

Men are selected for Antarctic assignments initially on the basis of competence in an occupational specialty. All applicants also are subjected to thorough physical and psychiatric examinations. Since each station must be a completely self-sustaining community for many months, a variety of scientific, technical, and military occupations, such as glaciologists, ionospheric physicist, meteorologist, electronics technician, physician, mechanic, and cook, are represented.

#### PROCEDURE

Method. Attitude questionnaires were administered on two occasions to a

number of Navy-scientist groups from three expeditions which wintered over in the Antarctic.<sup>1</sup> In the first two expeditions, questionnaires contained 119 items which assessed living conditions, motivational states, feelings of personal usefulness, quality of relationships among group members, and group productivity or effectiveness. Responses were given on continuous five-category rating scales. As the authors wished to delineate and measure a number of attitude areas, homogeneous clusters of items were derived for study. Scales were revised for use in the third expedition as described in the Test Administrations section below.

To form attitude clusters, one of the authors grouped all items by similarity of content or reference; items which did not appear to cluster with other items were dropped. Ten item clusters were thus formed and each given a descriptive label. The second author then assigned each questionnaire item to one of the named clusters, omitting those items which were unrelated to any cluster. Eighty-four percent agreement was achieved by the two authors in assigning items to clusters.

All original 119 items were intercorrelated for both test administrations. Based on these data as well as the a priori clusters derived by the authors, nine attitude clusters, consisting of a total of 72 items, were finally accepted for use in the present study and were given the following designations: four cluster scales having reference to individual adjustment were Physical Adjustment, Motivation, Usefulness, and Boredom; five clusters having reference to group relationships and effectiveness were Compatibility, Teamwork, Efficiency, Achievement, and Egalitarian Atmosphere.

Table 1 provides brief descriptions of the nine scales and lists for each scale the two items correlating most highly with that scale. Other items in the scales are similar to the examples given.

TABLE 1

Descriptions of Attitude Scale Clusters

	<u>Item-Total Correlation<sup>a</sup></u>
<u>Physical Adjustment:</u> degree of adjustment to climatic and living conditions.	
Does your Arctic clothing tire you out quickly?	.54
Does your Arctic clothing interfere with the performance of your job?	.53
<u>Motivation:</u> interest in remaining or returning on Antarctic expedition.	
Do you wish you had never come to the Antarctic?	.69
Would you like to go on another Arctic or Antarctic expedition after you return from this one?	.69

<sup>a</sup>Estimated from each item's correlation with other items in cluster.

<sup>1</sup>The questionnaires were the Attitude Study and Group Behavior Description constructed by Herbert Zimmer, 1957.

TABLE 1 (continued)

	<u>Item-Total Correlation</u>
<u>Usefulness</u> : feeling that job is important and that personal gain will be derived from participation.	
Do you think your mission is important enough to justify your spending all this time in the Antarctic?	.69
How much of the knowledge and experience you gain on this Antarctic expedition do you think you will be able to use in one form or another after you return?	.68
<u>Boredom</u> : lacking things to do, time dragging.	
Do you find yourself in need of something to do in your spare time?	.59
Are you bored?	.59
<u>Compatibility</u> : perception of group members as mutually congenial and preferred as personal friends.	
The members of my group are the kind of people I like to spend a lot of time with.	.57
There is a pretty good feeling between us here.	.57
<u>Teamwork</u> : perception of group members as cooperative and each carrying his share of the work.	
Members of this group work well together as a team.	.69
Everybody pulls together to get a job done.	.68
<u>Efficiency</u> : perception of group as well organized, having definite goals and scheduled activities.	
This group is confused and disorganized.	.63
Everything we do is planned well ahead of time.	.61
<u>Achievement</u> : perception of group accomplishment and members' pride in same.	
We take a lot of pride in what this group has been able to achieve.	.70
This group does not accomplish much.	.69
<u>Egalitarian Atmosphere</u> : perception of mutual respect, status leveling, and democratic procedures within group.	
Everyone here can have his say.	.48
The group <u>as a whole</u> makes important decisions.	.47

Subjects. Nine groups from three Antarctic expeditions were chosen for study. Groups ranged in size from 14 to 40, and the average size was 28 men.

The average composition of groups was as follows: 58% Navy enlisted men, 7% officers, and 35% civilian technicians and scientists. Mean age and years job experience were 27 and 7, respectively.

Test Administrations. Stations, scales, and testing times were the same for Expeditions I and II. The nine scales described in Table 1 were administered twice during the year to three groups in each of two expeditions. Questionnaires were given at mid-winter, after three to four months of isolation and restricted activity, and again at the end of winter, several months later, when limited outdoor activities had been resumed.

In Expedition III the first testing was done at the early winter period, after one to two months of isolation, rather than at mid-winter. The second administration was at the end of winter. Because the staggering difficulties of data collection in the Antarctic dictated a reduction wherever possible in the length of questionnaires, the attitude questionnaire was revised and shortened prior to the testing in Expedition III. Generally, items with high item-total scale correlations were retained; others were dropped or replaced with items known to correlate highly with that cluster.

Internal consistency estimates, test-retest reliabilities, and intercorrelations for the original and revised scales are shown in Table 2. It is apparent that most of the nine revised scales were quite comparable to their original counterparts. An exception was the revised Usefulness Scale which had lowered correlations with other scales and lowered internal consistency. Test-retest reliabilities were generally lower for Expedition III, perhaps because of the longer time interval between testings.

Through information available from official reports, supervisors' records, assessments by psychiatric teams at the sites, and post-expedition interviews with members and station leaders, it was possible to identify that group in each expedition which was least effective. The principal identifying characteristics of least effective stations were persistent difficulties keeping essential station equipment operating, reports by station leaders of repeated open conflicts between group members, or low motivation and morale reported at the end of the year by observers at the scene. Groups classified as least effective from independent reports were Group C of Expedition I, Group F of Expedition II, and Group G of Expedition III.

Data from Expeditions I and II were analyzed first as a unit; it was intended that data from Expedition III would then be evaluated in the light of the earlier findings. An assumption was made that if the results from Expeditions I and II could be essentially replicated under the modified conditions of Expedition III, more confidence could be placed in the generality of the findings.

## RESULTS

Scale means and standard deviations for all respondents at each test administration are presented in Tables 3, 4, and 5. An analysis of attitude changes after several months of isolation and reduced activity also is shown for the three expeditions in the Tables.

Significance of changes in means were evaluated by the t-technique for correlated means (McNemar, 1962); only those subjects who were tested on both occasions were utilized for this analysis. Results of the t-tests are indicated by asterisks placed between the values for the two test administrations. Changes in variance also were evaluated using the t-technique for correlated variances suggested by McNemar.

Of the nine attitude scales, the Compatibility Scale, which was designed to measure affective or social relationships among group members, and the Achievement Scale, which was designed to measure group accomplishment, most frequently showed significant changes from early or mid-winter to end of winter.

TABLE 2

Intercorrelations and Reliabilities of Original and Revised Attitude Scales

Attitude Scales	1	2	3	4	5	6	7	8	9	
1 Physical Adjustment		37 <sup>a</sup>	27	-10	21	16	09	07	12	Original
		16 <sup>a</sup>	05	-34	04	16	13	10	13	Revised
2 Motivation			59	-30	30	24	12	14	27	Original
			50	-28	17	07	05	15	32	Revised
3 Usefulness				-38	38	32	24	34	35	Original
				-25	14	-06	06	22	14	Revised
4 Boredom					-29	-29	-14	-20	-20	Original
					-02	-05	-13	-09	-04	Revised
5 Compatibility						78	55	64	57	Original
						70	38	61	41	Revised
6 Teamwork							62	74	57	Original
							60	60	51	Revised
7 Efficiency								64	21	Original
								60	58	Revised
8 Achievement									27	Original
									49	Revised
9 Egalitarian Atmosphere										
Internal	70 <sup>b</sup>	84	82	70	85	82	74	78	64	Original
consistency	53 <sup>b</sup>	81	46	63	84	80	67	88	75	Revised
Test re-test	71	81	71	51	55	51	58	54	55	Original
reliability	62	71	54	61	55	29	51	38	36	Revised

<sup>a</sup>Averaged product-moment correlations from two administrations.

<sup>b</sup>Coefficients from the generalized Spearman-Brown formula based upon average item intercorrelations were averaged over the two administrations.

TABLE 3

Means and Standard Deviations for Groups of Expedition I

	Time	Group A		Group B		Group C	
		Mean	S. D.	Mean	S. D.	Mean	S. D.
Physical Adjustment	1st	19.5	4.9	17.4	2.8	17.2	3.3
	2nd	18.9	3.0	17.3	4.2	17.2	2.6
Motivation	1st	14.6	3.4	18.0	5.2	21.8	5.0
	2nd	16.0	3.6	17.9	5.0	23.7	4.2
Usefulness	1st	14.9	4.4	15.2	3.8	21.1	6.0
	2nd	15.8	4.2	15.8	4.1	23.9	5.6
Boredom	1st	20.4	2.9	21.4	2.6	20.0	3.1
	2nd	21.1	3.3	20.3	3.1	19.0	3.2
N	1st	14		27		33	
	2nd	13		27		26	
Compatibility	1st	49.5	6.7	45.3	4.6	56.5	8.3
	2nd	56.0	7.5	51.6	7.1	57.5	12.9
Teamwork	1st	19.3	3.4	14.7	3.2	21.3	4.6
	2nd	23.2	5.1	17.2	3.0	22.3	5.3
Efficiency	1st	23.1	5.0	18.8	2.8	22.1	3.4
	2nd	24.6	4.1	19.0	2.5	22.9	3.9
Achievement	1st	10.7	3.4	7.1	1.8	11.2	3.0
	2nd	12.6	2.8	8.1	1.0	12.1	3.4
Egal. Atmosphere	1st	26.9	2.6	28.7	3.6	31.8	5.0
	2nd	26.4	4.6	30.2	4.7	33.0	6.2
N	1st	15		27		32	
	2nd	9		27		26	

\* Significant change at the .05 level by t-technique for correlated means and correlated variances.

\*\* Significant change at the .01 level; low scores favorable, except Boredom.



TABLE 4

Means and Standard Deviations for Groups of Expedition II

	Time	Group D		Group E		Group F	
		Mean	S. D.	Mean	S. D.	Mean	S. D.
Physical Adjustment	1st	17.3	3.1	17.8	4.3	18.5	4.8
	2nd	19.7	3.4	17.4	4.9	19.7	4.7
Motivation	1st	17.4	4.4	16.0	5.2	18.9	5.6
	2nd	18.1	5.3	19.0	6.0	19.2	4.8
Usefulness	1st	15.2	4.5	17.2	4.9	18.7	6.2
	2nd	16.2	6.1	20.0	6.6	20.3	6.5
Boredom	1st	22.6	2.6	22.1	2.8	19.9	3.7
	2nd	22.3	2.2	21.1	3.6	18.1	3.6
N	1st	14		28		37	
	2nd	11		26		26	
Compatibility	1st	41.9	5.0	47.7	9.1	50.8	9.1
	2nd	47.0	8.6	54.0	11.8	57.6	9.4
Teamwork	1st	13.3	3.4	16.1	4.2	18.3	5.0
	2nd	15.9	3.9	19.2	4.7	23.8	5.0
Efficiency	1st	17.8	3.1	18.9	4.4	24.3	4.3
	2nd	18.8	3.0	19.9	2.6	24.7	4.7
Achievement	1st	6.2	1.9	8.3	2.9	10.8	2.9
	2nd	8.0	2.4	10.2	2.9	12.7	3.9
Egal. Atmosphere	1st	22.4	3.6	25.5	4.2	26.1	4.7
	2nd	24.8	4.6	29.4	6.6	29.5	4.5
N	1st	14		28		35	
	2nd	11		26		24	

\* Significant change at the .05 level by t-technique for correlated means and correlated variances.

\*\* Significant change at the .01 level.

TABLE 5

Means and Standard Deviations for Groups of Expedition III

	Time	Group G		Group H		Group I	
		Mean	S. D.	Mean	S. D.	Mean	S. D.
Physical Adjustment	1st	14.3	3.3	17.5	3.7	17.5	3.3
	2nd	14.7	4.5	16.5	2.5	16.1	3.3
Motivation	1st	14.3	5.0	16.5	4.9	16.3	6.2
	2nd	15.2	6.2	18.9	5.3	16.8	6.4
Usefulness	1st	20.0	3.7	18.2	5.7	21.0	5.8
	2nd	22.6	5.9	22.7	5.1	25.6	6.0
Boredom	1st	22.4	4.6	22.0	4.7	22.4	6.2
	2nd	20.7	5.2	19.2	4.0	19.6	5.0
Compatibility	1st	28.7	7.0	27.2	5.9	39.3	11.6
	2nd	40.9	7.6	32.0	6.2	40.6	10.2
Teamwork	1st	20.7	4.6	19.4	3.3	23.8	7.7
	2nd	29.8	6.1	23.4	4.4	25.2	6.9
Efficiency	1st	28.5	6.1	26.5	4.9	24.8	7.2
	2nd	38.1	7.6	32.9	5.1	29.8	8.9
Achievement	1st	14.1	4.5	13.1	4.3	15.1	4.1
	2nd	23.1	6.2	18.4	4.9	19.5	7.4
Egal. Atmosphere	1st	20.4	4.5	21.5	5.1	20.6	7.4
	2nd	31.9	6.6	27.7	6.0	23.2	8.5
N		32		13		18	

\* Significant change at the .05 level by t-technique for correlated means and correlated variances.

\*\* Significant change at the .01 level.

Six of the nine groups showed significant changes in mean scores on these two scales. Four groups changed significantly on the Teamwork and Egalitarian Atmosphere Scales and three groups on the Efficiency and Usefulness Scales. The Motivation, Boredom, and Physical Adjustment Scales evidenced one or no significant changes.

In general, mean scores for the four measures reflecting individual status remained homogeneous during prolonged isolation while one or more measures reflecting group status varied significantly over time for almost all of the nine groups. These consistent attitude changes in the group status measures indicated that deterioration of group cooperation and accomplishment typically, but not necessarily, occurred in Antarctic groups toward the end of the long winter.

There were few significant changes in variance from first to second test administrations. Slight but consistent trends toward increased variance could be noted for certain scales and groups, but overall the attitude measures were relatively homogeneous with respect to variance over the two test periods.

Comparisons of less effective groups with relatively effective ones for the end of winter test administration are shown in Table 6. The t-values and significance levels for differences between the least effective group and the other two groups in each expedition are indicated for the nine attitude measures.

TABLE 6

Differences between Least Effective and Other Groups by the t-Technique<sup>a</sup>

	Expedition I		Expedition II		Expedition III	
	Group C versus Group A	Group C versus Group B	Group F versus Group D	Group F versus Group E	Group G versus Group H	Group G versus Group I
	t	t	t	t	t	t
Phys. Adjust.	-1.79 <sup>b</sup>	-.18	.03	1.71	1.71	1.26
Motivation	5.96**	4.53**	.57	.08	-2.04*	-.89
Usefulness	4.99**	5.89**	1.82	.15	-.06	-1.82
Boredom	1.86	1.52	4.27**	2.98**	1.04	.72
Compatibility	.41	2.03*	3.29**	1.21	4.11**	.12
Teamwork	-.45	4.25**	5.01**	3.33**	3.30**	2.36*
Efficiency	-1.07	3.38**	4.47**	4.39**	2.67**	3.35**
Achievement	-.38	5.38**	4.40**	2.61*	2.70**	1.86
Egal. Atmos.	3.30**	1.85	3.04**	.05	2.09*	3.82**

<sup>a</sup>Probabilities for all comparisons are based upon two-tailed tests. One asterisk indicates significance beyond .05 level, and two asterisks indicate significance beyond .01 level.

<sup>b</sup>Minus signs indicate that the difference was in a favorable direction.

The Teamwork, Efficiency, Achievement, and Egalitarian Scales consistently discriminated between least effective and other groups, showing at least one highly significant difference between means in each of the three expeditions. The Compatibility Scale discriminated for one of the two comparisons in each expedition. Usefulness discriminated only for both comparisons of Expedition I while Boredom discriminated only for both comparisons of Expedition II. Motivation discriminated for both comparisons in Expedition I but discriminated in the opposite direction for one comparison in Expedition III. Physical Adjustment did not discriminate for any of the six comparisons.

#### DISCUSSION

The measurement of group effectiveness in isolated natural settings presents obvious methodological and practical difficulties. What constitutes effective group performance? How can differences in effectiveness among groups best be measured?

Fortunately, gross breakdowns in group organization, integration, and cooperation have been so rare in Antarctic groups that such critical incidents do not provide a generally useful criterion on which to differentiate group performance. It has been difficult to assess the extent to which Antarctic groups have fulfilled pre-determined goals and have generated and accomplished other goals spontaneously. It is usually not known in advance how much a group will be required to accomplish except in a broad sense. The fact that unpredictable natural events can disrupt achievement efforts and that projects and physical settings differ somewhat from group to group make it difficult to establish common standards for all groups. In addition, group adaptation and performance are recognized as continuing and varying processes. Based on sources of data external to the group, only gross distinctions have been possible thus far where a combination of circumstances has clearly pointed to relatively inferior group accomplishment.

It would undeniably be very helpful to have objective indicators of group productivity in natural isolated work groups. It seems unlikely, however, that many such indices will become readily available in the near future. The authors take the position that until more precise ways of gauging group productivity can be developed, by far the most useful estimates of overall group performance will be obtained from knowledgeable participants in the group enterprise. The only available source of information concerning the group's performance over the entire year is the station membership itself. Furthermore, it seems reasonable that station members are as capable as anyone of observing whether or not a group is friendly, cooperative, or efficient. An attitude inventory or questionnaire is not, of course, a new technique for obtaining this type of information. Questionnaire evaluations are used extensively in industrial, military, and laboratory settings to obtain relevant information about group behavior, and the usefulness of the questionnaire approach has been demonstrated in many previous studies.

A great deal of research will be required to identify those personal characteristics of group members, leadership practices, and manipulatable environmental conditions which will make possible reasonably accurate prediction of small group adaptation and performance in isolated or stressful settings. The present study may have contributed toward development of simple measures of important dependent variables which appears to be a necessary step in advancing the above aims.

In this study Antarctic groups exposed to long-term isolation from the outside world clearly evidenced measurable deterioration in their social relationships and work effectiveness during the latter part of their confinement. Measures of individual adjustment and satisfaction did not consistently show a similar decline.

Seaton (1962), utilizing the same five group status measures employed in this study, reported similar deterioration of affective relationships in Army

teams exposed to short-term hunger deprivation while temporarily isolated on the Greenland Icecap. Formal organization, social control, and mutual support also declined. Seaton suggested that these changes were consequences of social withdrawal or restriction of relationships to few persons rather than results of changes in the individual's attitudes toward others or the task.

Torrance (1957) observed typical changes in sociometric structure under the stress of survival training. Social structures progressed from formal structures to informal structures to no structure.

Under the conditions of long-term restrictions in physical activity and social stimulation experienced in Antarctic groups, maintenance of group organization, harmony, and efficiency presents a manifestly difficult problem. The rigors and privations of Antarctic small station life would appear to demand extraordinary personal qualities and leadership abilities in the participants and to fully justify efforts to select highly qualified members. Research also is needed to identify organizational and environmental supports which can help overcome the stressful and debilitating effects of prolonged group isolation and confinement.

#### SUMMARY AND CONCLUSIONS

The systematic study of interpersonal relations and productivity in natural isolated groups requires measurement techniques which are practicable for administration in groups operating under variable or extreme environmental conditions. In the present study simple questionnaire scales designed to measure group cooperation and effectiveness demonstrated acceptable reliability and were shown to relate consistently to an independent criterion of group effectiveness. Significant changes in social relations and group accomplishment were recorded in several of the Antarctic groups studied.

Maintenance of group organization, harmony, and efficiency under conditions of long-term isolation and confinement such as exist at Antarctic stations appears to be a very difficult but not impossible task.

#### REFERENCES

- McNemar, Q. (1962) Psychological Statistics (3rd ed.). New York: Wiley.
- Seaton, R. W. (1962). Small group experimentation in the Arctic. Paper presented to the Annual Meetings of the American Psychological Association, St. Louis, Missouri.
- Torrance, E. P. (1957). What happens to the sociometric structure of small groups in emergencies and extreme conditions? Group Psychother., 10, 212-20.

#### ACKNOWLEDGMENT

Statistical assistance by Frank Thompson is gratefully acknowledged.